DREDGE
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EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES

PART III A

HANDBOOK FOR DREDGING AND DREDGED MATERIAL DISPOSAL IN ONTARIO - LEGISLATION, POLICIES, SEDIMENT CLASSIFICATION AND DISPOSAL OPTIONS

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FOREWORD

In 1976, the Ontario Ministry of Environment (OMOE) published the guideline "Evaluating Construction Activities Impacting on Water Resources" as an aid in the assessment of the environmental impact of construction activities. Information gained since 1976 now warrants a revision of the original document.

The revised guidelines have been divided into five parts, as follows:

Part I:	Guidelines for construction of hydrocarbon transmission and distribution pipelines crossing water courses (March 1984)
Part II:	Guidelines for construction of highways and bridges (March 1984)
Part III:	Handbook for dredging and dredged material disposal in Ontario A,B,C A - Legislation, Policies, Sediment Classification & Disposal B - Dredging, Transport and Monitoring C - Sediment Sampling and Laboratory Analysis (November 1990, Revised January 1994)
Part IV:	Guidelines for marine construction projects (April 1986)
Part V:	Guidelines for small-scale waterfront projects (April 1986)

This handbook (Dredging and Dredged Material Disposal - Part III) has been prepared to assist dredging project proponents, OMOE staff and staff of other regulatory agencies in the selection of safe and appropriate management methods based on dredged material characteristics and current OMOE legislation. This document is intended to be a reference handbook of dredging-disposal activities, the details of which may not be required on a routine basis. The current revision incorporates the new sediment evaluation procedures from the Provincial Sediment Quality Guidelines (Persaud *et al.* 1992).

Mention of trade names and commercial products in this handbook does not constitute endorsement.

ACKNOWLEDGEMENTS

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Tammy Lomas and Stephen Petro of the Water Resources Branch, Ontario Ministry of the Environment coordinated editorial revisions to the report.

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INTRODUCTION

Environmentally sound marine construction practice requires that every effort be made to preserve the physical and biological integrity of Ontario's waterbodies in accordance with the provincial goals - "To ensure that the surface waters of the Province are of a quality which is satisfactory for aquatic life and recreation" (Ontario Ministry of the Environment, 1978).

The aim of this Ontario Ministry of Environment handbook is to provide an overview of the management options for the handling of dredged material in the Province of Ontario. These guidelines were developed to protect the receiving environment according to the physical, chemical and biological quality of the material being dredged. Recognition is given, where appropriate, to the potential re-use of certain materials.

Dredging for the purposes of this handbook is identified as the planned, mechanical movement of material located below the surface of a waterbody, or at the land/water interface. These guidelines apply to all forms of dredging.

The following sections review the federal, provincial and municipal legislation and policies and as well, sediment classification and disposal.

Dredging activities undertaken by the provincial and municipal governments are subject to the Environmental Assessment Act. Federal activities may be reviewed under the Federal Environmental Assessment and Review Process. Other statutes that regulate dredging activities are also presented in the handbook.

Sediments are classified into two groups, contaminated or uncontaminated, based on a set of numerical guidelines. Once the sediments have been evaluated, several disposal options are available and depending on the degree of contamination, one method is selected.

1.0 FEDERAL LEGISLATION AND POLICIES

This category can be divided into two groups: federal legislation applying to all proponents, and legislation and policies applying only to federal government departments.

Environmental Assessment and Review Process

The Federal Environmental Assessment and Review Process (EARP) is an Order-in-Council, intended to ensure that the impact of any federal project, program or activity is assessed early in planning stages before commitments are made. The process applies to any proposal undertaken or financed by the federal government, involving lands (including the offshore) that are administered by the Government of Canada, or which concerns any proposal which has the potential to cause an environmental effect on an area of federal responsibility.

The federal proponent initiating a project is responsible for assessing the significance of the environmental impacts and public concerns, and the implementation of required mitigative measures. In addition, the proponent must satisfy all other legislation or regulatory requirements related to the development and implementation of the project.

EARP is 3 stage process: 1) The proponent undertakes an Initial Assessment (which may only be a simple checklist) outlining the environmental impacts. If there are no significant impacts or public concerns the project may proceed incorporating any necessary mitigative measures; 2) If Stage 1 has identified significant information gaps, or the project needs further assessment, the proponent conducts a more detailed review called an Initial Environmental Evaluation. If the proponent identifies no significant impacts, the project can proceed, implementing any mitigative measures; 3) If Stage 1 or 2 has identified significant impacts then the project is referred to the Federal Environmental Assessment and Review Office for formal review.
Although EARP is a self assessment process, Federal proponents may consult with Environment Canada to obtain environmental data, appropriate

guidelines/regulations/codes, technical advice and comment to ensure a thorough review has been done.

Several pieces of federal legislation also have to be considered by the proponent. Some of the legislation has direct application to dredging and dredged material disposal projects. Other acts may have only peripheral impact or application under very limited cases.

Canadian Environmental Protection Act

The Canadian Environmental Protection Act provides for the regulation of federal works, undertakings, and federal lands and waters, where existing legislation administered by the responsible federal department or agency does not provide for the making of regulations to protect the environment. In addition there are provisions for the creation of guidelines and codes for environmentally sound practices and for setting objectives for desirable levels of environmental quality. Either of these provisions could be applied to dredging and disposal activities.

Migratory Birds Convention Act

The Migratory Birds Convention Act prohibits the disposal of any substances harmful to migratory birds in any waters or areas frequented by migratory birds.

Fisheries Act

Two sections of this Act could specifically apply to dredging projects: Section 33 regulates the dumping of any substance which is deemed "deleterious", in waters frequented by fish. Section 31 regulates the alteration of fish habitat including alteration, disruption or destruction of habitat (where habitat can range from spawning areas and feeding areas to water quality and quantity). Although the administration of the Fisheries Act is the responsibility of the Department of Fisheries and Oceans, the administrative activity for Section 33 is carried out by Environment Canada and through a long established understanding Section 31 is administered by the Ministry of Natural Resources.

Navigable Waters Protection Act (NWPA)

The NWPA prohibits any work on, in, upon, under, through or across a navigable waterway. "Work" has been defined to include the dumping of fill or the excavation of materials from the bed of navigable waters. An application for exemption is required if dredging or disposal operations are undertaken. Prior to granting the exemption, Transport Canada reviews the implication of the dredging or disposal operations for potential impact on navigation.

Canada Shipping Act

The Canada Shipping Act regulates the discharge from ships (open water disposal) of any pollutant specified in regulations of the Act. Most of these pollutants are those listed in the OMOE guidelines. A ruling under Section 728 of the Act may be required.

Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement is an agreement between Canada and the United States to restore and enhance the water quality of the Great Lakes. Annex 7 of the Agreement specifies that the two governments will develop and implement programs and measures to ensure that dredging activities will have a minimum adverse effect on the environment. Annex 14 of the agreement provides for the governments, in cooperation with State and Provincial Governments to identify the nature and extent of sediment pollution in the Great Lakes System and subsequently develop and evaluate methods to remedy such pollution.

2.0 PROVINCIAL LEGISLATION AND POLICIES

Environmental Assessment Act

The Environmental Assessment Act requires that proponents of major projects outline the details of the project and identify how construction, location and ultimate utilization will affect current and future uses of that area. Water quality effects, biological effects, and social and economic factors must be considered.

Environmental Protection Act

The Environmental Protection Act regulates the "spilling" or discharge of pollutants into the natural environment, and protects human health and plant and animal life against injury and damage.

Ontario Water Resources Act

The discharge of any material into water that may impair water quality or cause injury to any person, animal, bird or other living thing is prohibited by the authority of the Ontario Water Resources Act.

Beds of Navigable Waters Act

Title to the beds of navigable waters is restricted through grants by the Lieutenant-Governor. Ownership of lands bordering navigable waters does not provide right of use of the beds of those waters.

Public Lands Act

The management, sale and disposition of public lands is controlled by the Public Lands Act. The Ontario Ministry of Natural Resources may define zones as open, deferred or closed for disposition.

Conservation Authorities Act

The restricting or regulating of water through the construction of dams or diversions or depressions in rivers and streams and the placing and dumping of fill within the watershed is placed under the jurisdiction of the local Conservation Authority.

Beach Protection Act

The Beach Protection Act refers to taking of sand from the bed, bank, beach, shore or waters of rivers, lakes and streams and requires a license from the local Ministry of Natural Resources District Manager.

Drainage Act

The Drainage Act provides information on procedures for the construction, improvement and maintenance of drainage works.

ublic Health Act

The Public Health Act is concerned with public water supplies and maintaining their quality to protect human health and assures that projects not impinge on the operation of water treatment facilities.

Lakes and Rivers Improvement Act

Approvals for the repair, reconstruction or removal of dams or other structures affecting lakes or rivers is required from the Ontario Ministry of Natural Resources. Furthermore, the deposition of any substance or refuse into a lake or river or on the shore is prohibited by this Act.

3.0 MUNICIPAL LEGISLATION AND POLICIES

These will affect a project where shoreline or upland disposal is to be used. In these cases, municipal zoning or planning guidelines may have to be considered and taken into account. Since each municipality may have different requirements, the proponent is advised to contact the appropriate municipal office during the initial screening stage of the project. Contacting the municipal office will also permit the proponent to assess the need for public information sessions to facilitate public acceptance of the disposal facility.

4.0 SEDIMENT CLASSIFICATION AND DISPOSAL OPTIONS

4.1 Introduction

The need to characterize and classify sediments prior to dredging in order to determine the most environmentally sound disposal options dates back to the 1960's. The U.S. Federal Water Pollution Control Administration (FWPCA), in Chicago characterized light, moderate and heavy sediment pollution according to ranges of chemical concentrations in 1968. The concentration ranges were selected based on observed responses to indigenous benthic population (i.e., abundance and diversity). The FWPCA, Cleveland office, completed a similar exercise in 1969, and the two categorizations were combined as the Jensen criteria and adopted by the U.S. EPA in 1971. In the early 1970's, the Ontario Water Resources Commission drafted sediment guidelines based on those developed by the U.S. EPA, but modified them to reflect Ontario's experience with sediment data from Canadian harbours on the Great Lakes. These were revised in 1992 with the publication of new sediment quality guidelines ("Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario"). The Ontario practice has differed from that of the U.S. in that each dredging project has been and continues to be considered on a case by case basis. Some flexibility is allowed according to local conditions and the nature of the project under evaluation.

Various Ontario Acts and Regulations have an impact on dredged material disposal or use. In the Guidelines, the use of the Ontario Water Resources Act and the Environmental Protection Act, administered by the OMOE, are tlined where appropriate. Compliance with these Guidelines does not exempt a dredging proponent or his agent from other federal, provincial or municipal legislation. However, it is likely that use of the Guidelines will assist the proponent in meeting legislative requirements of other agencies and help expedite proposed projects.

The OMOE strongly recommends that dredging proponents, or their agents, contact and discuss project proposals with OMOE Regional staff, as an initial step, to obtain regulatory and technical advice. This will assist in avoiding potential problems and delays.

4.2 Application Requirements

To facilitate the review of dredging/disposal applications, the proponent is requested to submit the following:

- A brief outline of the project proposed and the requirements of the project.

- Detailed map of the dredging project site; the map should clearly indicate bathymetry, relation of major landmarks to site, scale (1:500 or 1:1000), direction of north and sample collection sites.

- Description of the nature of the material to be disposed; this should include the results of bulk chemical analyses; results of other tests conducted to further evaluate the materials such as bioassessment testing, geotechnical testing, testing of settleability or leachability etc. This description should also include a discussion of the latest results compared to earlier surveys and an up-dated tabulation of results for the project site.

- A discussion of the proposed disposal alternatives and an evaluation of the disposal mode proposed, including site evaluation, and if containment is proposed, facility design, facility management and facility de-commissioning.

- Generalized map of the disposal area indicating the proposed disposal facility in relation to the project site and the proposed transit routes to the disposal facility.

- If possible, an aerial colour photograph of the project site should be included.

The following example illustrates the information package.

Description of Project

In 1984, Public Works Canada proposed maintenance dredging of portions of the Burlington Ship Canal from Hamilton Harbour into Lake Ontario, specifically to remove accumulated sand. Two areas were to be dredged comprising 25,000 m^3 in the north section and 2,000 m^3 in the south section of the canal.

It was determined that Trans Northern Pipelines owned a pipeline crossing the mouth of the canal at the lakeward end which might be impacted by the dredging. Its elevation was checked in the field and was found to be safely below the limit of dredging.

Discussion of Testing for this Project

Three sediment samples were collected for analysis: one from the north section, one from the south section and one control from Hamilton Harbour. The south sample contained 100 ng/g of PCBs (compared to Lowest Effect Level of Provincial Sediment Quality Guidelines of 70 ng/g). Other parameters and locations were within the guidelines.

OMOE requested further sampling to delineate the extent of the contamination: /e samples from the north section and three from the south. PCB contamination was verified in the south section at a different location than had been sampled the first time. Therefore, it was decided that the entire 2,000 m^3 of material would be disposed of in the Hamilton Harbour Commission's confined disposal facility. Contamination (126 ng/g of PCB at a location close to where 40 ng/g of PCB had been found the first time) was determined in one sample from the north section.

Disposal Alternatives

It was decided to isolate an area 20 metres east and west of the sampling point and extending the full width of the dredging area from north to south for disposal in the confined disposal facility (CDF) located inside Hamilton Harbour. The remainder of the dredged material, which met OMOE guidelines for open water disposal, was barged to an established off-shore disposal site, about 1 km southeast of the canal in Lake Ontario. This location had been previously designated for uncontaminated dredged material disposal. The City ; Hamilton water treatment plant intake was 4 km from the disposal site, therefore no impact on the water supply was anticipated. Routine monitoring of turbidity levels at the intake revealed no impact of the spoils disposal.

Monitoring Program

The OMOE chose to monitor the dredging activities associated with the Burlington Canal because of the potential impacts to water quality uses and aquatic biota. Open water disposal operations may result in dispersion and movement of sediment related contaminants and/or disruption of the bottom habitat at the disposal site.

The monitoring program had several sampling components:

- pre and post disposal surficial sediment samples.

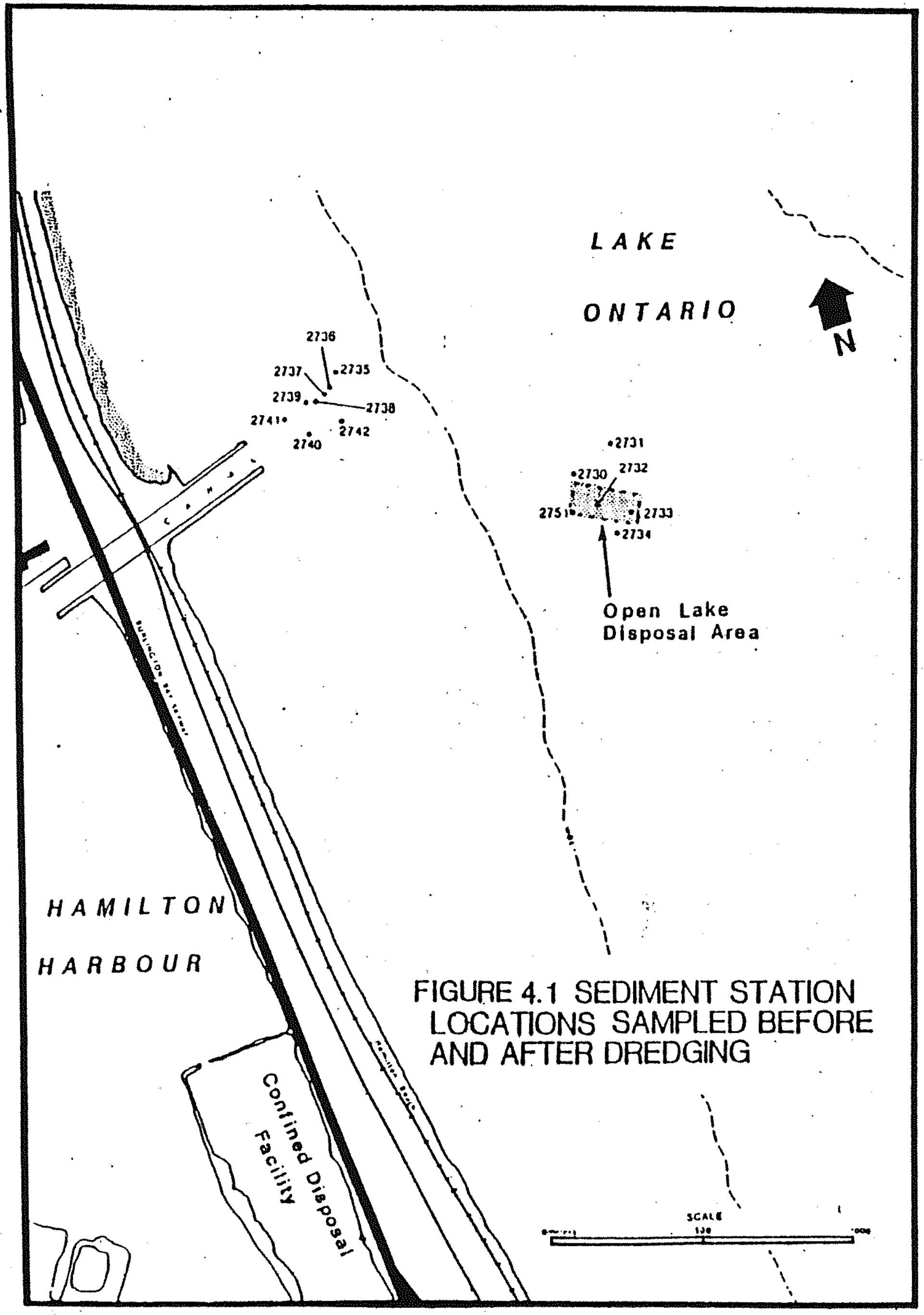

FIGURE 4.1 SEDIMENT STATION LOCATIONS SAMPLED BEFORE AND AFTER DREDGING

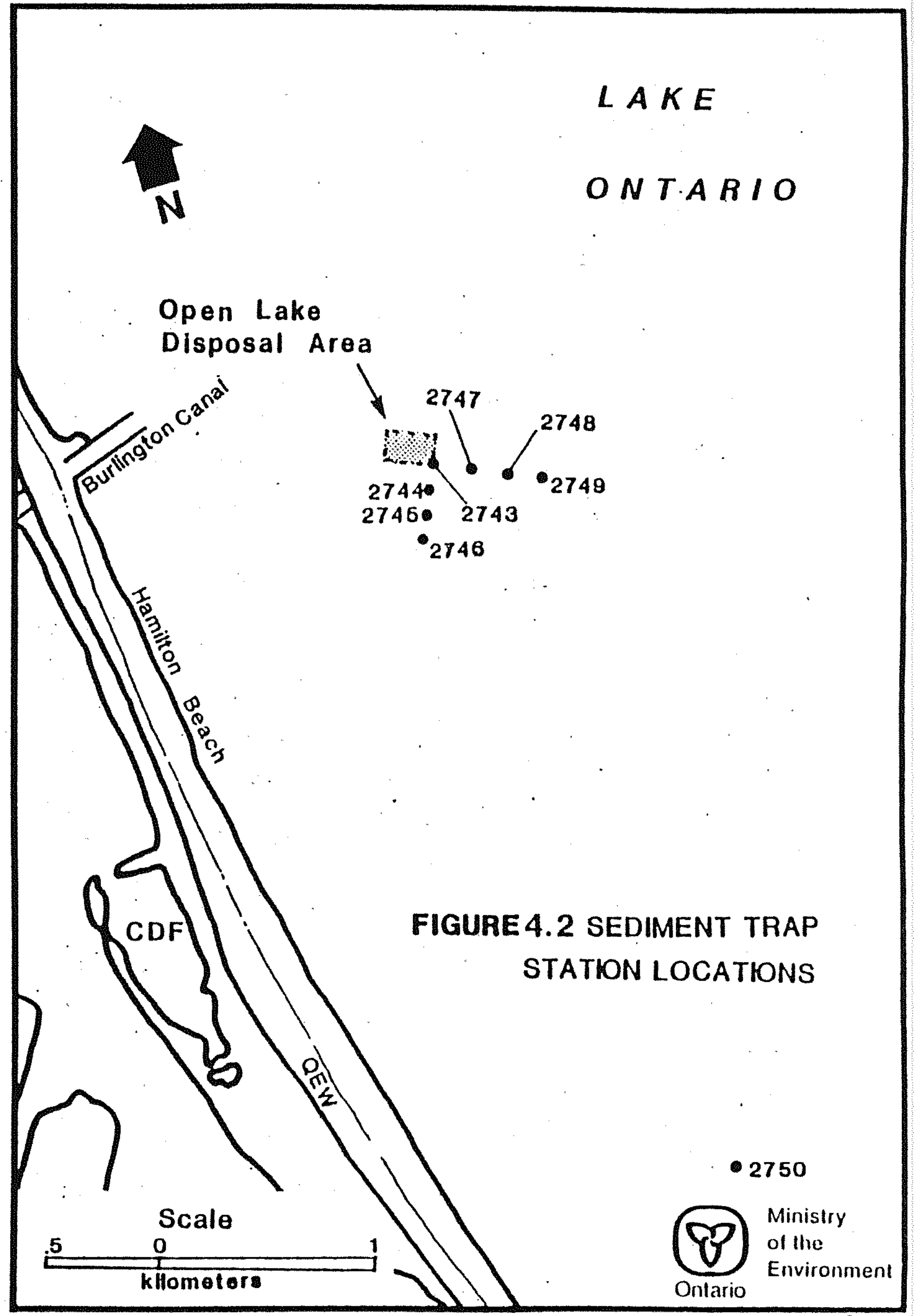

FIGURE 4.2 SEDIMENT TRAP STATION LOCATIONS

- suspended sediment sampling with both sediment traps and centrifuging of surficial water.
- visual description both aerial and diver.
- transmissometer measurements (refer to Figures 4.1 and 4.2).

Recommendations

1. Study has shown that there is a need for site specific monitoring. Each dredging project and disposal technique should be monitored because certain factors (i.e. prevalent wind direction, dredging location embayment vs. open lake, navigational activities etc.) influencing each site may vary.

2. When the chemical and physical characteristics of the 'newly' exposed sediment is unknown, coring for sediment should be employed. The 'newly' exposed sediment may be contaminated and perhaps may be a potential environmental problem.

4. Silt curtains or a similar contaminant device may be required at a dredge site to control movement of suspended material. Plumes were observed at the dredging site.

5. Biological studies (e.g., community structure analysis) may be required to assess the potential environmental impacts to aquatic biota. Sediment bioassays may also be required to assess the toxicity and bioaccumulation of contaminants in sediments.

The methodology and results from the monitoring study are provided in a 1989 OMOE report (Lomas and Persaud, 1989, unpublished).

4.3 Dredged Material Classification Process For Disposal

4.3.1 Application

This classification process differentiates dredged material on the basis of chemical and physical characteristics. The dredged material management options include: open water disposal, disposal on land and confined disposal.

The classification process applies to dredged material originating from commercial, industrial or public sector undertakings with the exception of agricultural drainage activities managed by Ontario municipalities under the Drainage Act, and resource recovery activities under the Beach Protection Act administered by the Ontario Ministry of Natural Resources. The disposal of dredged material from agricultural drainage activities is governed by guidelines established by the Ontario Ministry of Agriculture and Food.

Depending on the magnitude and location of small dredging projects of a non-commercial, non-industrial or non-public sector nature (e.g., cottage owners), they may be exempt from this classification process. Such exemptions would be made at the discretion of the appropriate OMOE staff. Dredged material from these exempted undertakings should be handled in the following manner:

- disposed of on-land, on-site, above the high water mark, and
- stabilized as soon as possible to prevent its re-entry into the waterbody.

4.3.2 Classification Options

The dredged material, depending upon its chemical and physical characteristics relative to the parameters presented in Appendix A, will be classified in one of the following categories:

A. suitable for open water disposal;

B. suitable for agricultural/residential/parkland ("Urban Residential Fill")

C. suitable for commercial/industrial ("Urban Industrial Fill")

D. contaminated material requiring disposal at a certified confined disposal facility (dewatering permitted);

E. severely contaminated material requiring specialized disposal at a certified confined disposal facility (with no dewatering) ("Controlled Fill" or "Hazardous Waste")

NOTE: Disposal alternatives B through E are determined on the basis of the procedure described in the Ministry's "Proposed Policy on Management of Excess Soil, Rock and Like Materials". These options are discussed in detail in that document and are not considered further here.

Selection of the disposal alternative is made on a case-by-case basis. The classification procedure is briefly described in the following section.

4.3.3 Classification Process

In this section, the disposal alternatives are discussed in the following terms:

- evaluation process,
- guidelines for the various options, and
- required analyses for the options.

OMOE concurrence and/or approval is required for each of these options. Compliance with these requirements does not exempt a dredging proponent or his agent from other provincial or federal legislation.

Analysis and evaluations, in addition to those outlined below, may be requested at the discretion of OMOE staff, after initial discussions with the proponent. These additional requirements may reflect the results of ongoing investigations in an area (e.g., the St. Clair River), where constituents not listed in Tables A.1, A.2, or A.3 of Appendix A have been identified in concentrations deemed hazardous or potentially hazardous. The evaluation process may require the use of bioassessment procedures. Information in this regard can be obtained by contacting OMOE.

Separation of dredged materials identified as "contaminated" from "uncontaminated" areas will be accepted if the proponent can demonstrate to the satisfaction of OMOE that:

- there are distinct areas or layers of sediments of different quality, and
- the necessary equipment and expertise are available to undertake the dredging operations.

4.3.3.1 Open Water Disposal (including beach nourishment)

The chemical quality of the dredged material is compared to the Provincial Sediment Quality Guidelines (Appendix A). The Sediment Quality Guidelines also require determination of the chemical quality of the sediments in the proposed disposal area. Evaluation of the suitability of disposal of dredged material depends on both the chemical quality of the dredged material and the existing chemical quality of the sediments at the disposal site. The evaluation procedure is described in detail in Appendix A. Selection of a disposal site is also governed by other considerations which are detailed in Chapter 5.0.

For dredged material with contaminants other than those in Tables A.1, A.2 or A.3 in Appendix A, the required method of disposal shall be determined by OMOE.

4.3.3.2 Confined Disposal

If the quality of the dredged material exceeds the relevant guideline levels of the Provincial Sediment Quality Guidelines as described in Appendix A, then the material is not suitable for open water disposal. Where dredged material is not suitable for open water disposal, the material is to be disposed of in a Confined Disposal Facility under the terms and conditions as described in

Section 6 of this report, or in a suitable upland disposal site under the ms and conditions described in the Ministry's "Policy for Management of Excess Soil, Rock, and Like Materials".

5.0 UNCONFINED OPEN WATER DISPOSAL

5.1 Introduction

Environmental, engineering and economic factors must be considered in the selection of an open water disposal site. To properly evaluate all potential sites, an impact matrix should be constructed which lists all of the criteria given in the following discussions. Where possible, all relevant data should be collected and collated, identifying areas where additional data collection may be necessary. Once sites have been evaluated on the basis of environmental impacts, the engineering and economics of haulage should be considered. The final "short-list" of sites should be discussed with staff from the OMOE Regional Office before data collection begins.

5.2 Site Selection Criteria

ıne site selection criteria were developed by the Dredging Sub-Committee of the International Joint Commission and are adapted with minor changes from their 1983 report (IJC, 1983).

Open water disposal sites should be located so as to avoid adverse impacts on:

- commerce and transportation, including commercial shipping, commercial fishing, pipeline and cable crossings and mineral and aggregate extraction;
- water intakes and outfalls;
- recreational uses and aesthetic values of the area;
- bottom topography so as not to adversely impact water circulation, current patterns, water level fluctuations, temperature regime, erosion and accretion patterns, and wave climate;
- sites of natural, cultural, archaeological, historical and

research significance;

- sanctuaries and refuges, breeding, spawning, nursery and feeding habitats, and passage areas for fish; and
- species of special interest such as threatened and endangered species.

In addition, open water disposal sites should:

- be compatible with the physical and chemical characteristics of the dredged material to the maximum extent practicable;
- utilize the smallest practicable disposal area;
- locate where current and past dredged material disposal has occurred, if these sites meet the other guidelines; and
- be selected to minimize the dispersal, erosion and slumping of the material so that only the smallest practicable part of the waterbody will be affected.

In applying the above-mentioned guidelines, the following considerations need to be addressed.

5.2.1 Impact on Various Commercial Activities

The sites and the transit routes from the project area should be selected so as to minimize interference with navigation, commercial fishing, submerged pipelines or cables, and sand, gravel or mineral extractions.

Information regarding the navigation channels in the Great Lakes is available from the Canadian Hydrographic Service and the U.S. National Oceanic and Atmospheric Administration (NOAA). Except for long, buoyed navigation channels extending several kilometres from shore, open lake disposal sites have typically been located 1 to 3 km away from navigation channels. It is believed that this distance is sufficient to prevent potential adverse impacts to the navigation channels. At locations where open lake disposal sites may be near commercial navigation sailing courses, minimum depths at Low Water Datum should be maintained, where feasible, in order to avoid grounding of vessels.

The minimum depth needed at any specific area should be at least equal to the eatest project depth which is charted at nearby navigation channels and harbours. The locations of other installations in the lake bottom, such as cables, pipelines, well-heads and commercial fishing net stakes, are identified on the nautical charts. In those cases where it may not be possible to maintain a minimum depth, open lake disposal areas should be registered with the Canadian Coast Guard, so that notice to mariners can be made. Published information is not generally available regarding the locations of sand, gravel or mineral resources and extraction activities in many areas of the Great Lakes. The current national and local permitting processes for disposal activities consider potential conflicts between open lake dredged material disposal and sand, gravel or mineral extraction.

5.2.2 Water Intakes and Outfalls

Use of the open water disposal site should not interfere with municipal, industrial or other types of water intakes and outfalls.

position of dredged material close to a water intake may increase the suspended solids load to a water treatment facility resulting in additional filtration requirements and costs. In some cases, material deposited in the vicinity of a water intake may not have an immediate effect, since most disposals occur during calm periods. Such material, however, can be resuspended during storms and affect the quality of water entering the intake. Mounds of material adjacent to an intake may also affect the proper functioning of the intake port as a result of physical obstruction to the port. Such mounds of materials can also attract certain species of fish which could be drawn into an intake.

Disposal of dredged material close to an effluent outfall may reduce the design dispersion characteristics of the outfall. Thermal, sewage and stormwater effluents require adequate mixing and transport via currents to prevent local water quality degradation. Mounds of dredged material could impede water movement in the vicinity of outfalls. Deposition of material resulting in blockage of a diffuser port on multiport outfalls may result in hydraulic overloading in the outfall. This would result in the diffuser caps being lifted off causing pressure drops at the remaining ports. Disposal in the vicinity of an outfall must be well outside of a safe zone designated by appropriate regulatory agencies and the agency and operator responsible for the outfall.

5.2.3 Recreational Uses and Aesthetic Values of the Area

An open water disposal site should be removed from areas of recognized recreational value such as beaches and wildlife areas. Disposal procedures should be designed so as to prevent or minimize any potential damage to the aesthetically pleasing features of the open water site, especially in regards to water quality. In some instances, clean dredged material may be considered suitable for beach nourishment. Disposal operations should be timed so as not to interfere with the peak recreational period.

5.2.4 Bottom Topography

Bottom topography influences the current patterns and water circulation and, therefore, plays a critical role in the ecology of lakes. Current patterns and water circulation (i.e., physical movement of water in the aquatic system) act to transport sediment and dilute dissolved and suspended chemical constituents. They also transport food and nutrients for aquatic organisms, provide directional orientation to migrating species and moderate extremes in temperature variations. Normal water fluctuations in a body of water affect water depth, water quality and are critical during spawning and feeding season. Prevalent accretion and erosion patterns in an area determine the bottom movement of material. Similarly, alterations in the wave climate can severely affect or destroy populations of aquatic animals and vegetation, modify habitats, reduce food supplies and change erosion patterns.

The dredged material should be deposited in a layer of suitable thickness at the disposal site to maintain natural bottom contours and elevation. In locations where mounding is an acceptable and ecologically desirable alternative, the shape and orientation of the mounds should be such that they 11 have a minimal impact on the prevailing current pattern and water circulation. The height and shape of mounds should be such as not to change existing depths and available fetches to adversely alter the wave climate of the area. The disposal of the dredged material should not result in enclosed areas of stagnant water, especially during low water cycles.

5.2.5 Sites of Historical Significance

Open lake dredged material disposal sites should be located away from areas of historical significance. Areas which are designated for their natural, cultural, archaeological, historical or scientific significance should be preserved in their existing state and managed so as to ensure continued access.

Natural areas include important examples of natural history in the form of plant and animal communities, landforms and geological features. Natural areas are tracts of water so little modified by man's activity or sufficiently covered that they contain native plant and animal communities believed to be representative of the pre-settlement landscape.

Historic and cultural resources include sites, areas, structures and objects of significance in history, architecture, archaeology or culture, e.g., sunken ships at the bottom of the Great Lakes. Sites, such as Fathom Five Underwater Park near Tobermory in Georgian Bay, are valuable because in their natural and undisturbed state they contain useful scientific information. In many areas, known historical sites are catalogued.

5.2.6 Sanctuaries and Refuges, Breeding, Spawning, Nursery and Feeding Habitats, and Passage Areas of Biota

The disposal of dredged material should not damage or destroy wetlands, sanctuaries, refuges or other areas designated and managed for the preservation of fish and wildlife. Improper disposal can reduce suitable habitats for many species of fish, wildlife and other biota, and interfere with spawning, migration or other life stage activities. Habitats can also be damaged by changes in water levels or circulation and by smothering. Appropriate surveys of the area should be conducted prior to dredged material disposal in such areas.

Applicable listings of species whose continued existence is considered to be threatened (i.e., those species designated as "rare and protected", "endangered", etc.) must be considered when selecting a disposal site. The disposal site must not adversely impact or interfere with the continued survival, reproduction or movement of such species or with management efforts to protect and rehabilitate such species. In addition, the disposal site must not adversely impact on or interfere with management plans or efforts for other species of special interest, such as those designated for intensive management or for introduction into the Great Lakes. Included in these considerations is protection of the forage base upon which these species are dependent.

5.2.7 Sediment Compatibility with Substrate at Disposal Site

Compatibility of the dredged material with the substrate at the disposal site is desirable in order to maintain the physical, chemical and biological state of the site. Some allowance for temporary changes in the substrate immediately following disposal can be made, but the major objective should be either an improvement or a quick return to the natural substrate type at the disposal site. The principle of "sediment matching" has been incorporated into the chemical evaluation procedure described in Appendix A.

"Sediment matching" has been used to minimize the impact of dredged material disposal on biota. This involves finding an area having substrate similar to that at the site to be dredged and disposing of the dredged material at that location. Sediment matching accomplishes two things:

1. it reduces the time required for re-colonization by biota because organisms from nearby areas should be adapted to conditions found in

the dredged material; and

2. it minimizes the time required for the establishment of a 'stable' biological community. The more similar the dredged material is to the surrounding area, the less time will be required to reach equilibrium with respect to both chemical and physical characteristics.

For the above two reasons, sediment matching should be employed where possible. However, there are circumstances that preclude the use of sediment matching. These include availability of disposal site substrate similar to the substrate to be dredged, economics and the need or desire on part of resource managers to create a new habitat type in an area.

If sediment matching is not practical, then consideration must be given to the type of sediment to be dredged and its compatibility with substrate at the disposal site. From a biological (habitat) perspective, sediment can be onveniently divided into three types: coarse - gravel, cobbles, boulders (with some fines); medium - sand with some fines; fine - silt and clay. Each of these has characteristic properties that make it valuable to different components of the biological community.

Coarse-grained sediments provide valuable habitat for many species of invertebrates, including those that are considered to be valuable as fish food, and generally provide good habitat for fish spawning, rearing and feeding.

Medium-grained sediments provide poor substrate for invertebrates, except for the few species that are capable of living in and on this unstable, nutrient-poor medium. Sand should not be deposited on another substrate type unless absolutely necessary. In cases where sand is deposited in deep water over fine sediment, there may be a long period of time over which the substrate will be altered unless the sand passes completely through the softer material.

Fine-grained sediments provide good substrate for benthic invertebrates, but are generally poor for fish spawning. If macrophyte growth occurs, then excellent habitat for spawning, rearing and foraging is provided for some species. Fine sediments, however, are usually nutrient-rich and can cause or aggravate enrichment problems.

5.2.8 Minimizing the Size of Disposal Area

Use of a site for dredged material disposal will have some impacts. In order to minimize the area affected, the size of the disposal area used should be kept to a minimum. Designation of the site must take into account that the area on the bottom will be a much larger impact zone than on the water surface. The disposal area must be easy to locate by the ship or barge operator, so the material can be placed inside the designated boundaries of the site. To facilitate this, the disposal area should be clearly marked. Accurate site location is particularly important if the deposited material is to be "capped" with other materials (to better match substrate, enhance habitat or help seal off pollutants). The capping material must be accurately placed over the previously deposited material.

5.2.9 Use of Current and Past Disposal Sites

Current and past open water disposal sites may have been chosen after consideration of factors such as distance from dredging site, proximity to navigation channels, etc. and may already be in compliance with these guidelines. The use of existing sites is preferred for localizing impacts of disposal. If there are some unavoidable adverse impacts from disposal, it would be preferable to continue to use existing sites where degradation has already occurred rather than affecting other areas. Since these sites have been used in the past, surveys can be done to determine actual impacts from their use by comparison with surrounding lake bottom outside the disposal area.

2.10 Minimizing Dispersal, Erosion and Slumping of Dredged Material at the Disposal Site

Retention of dredged materials at disposal sites can be fostered by proper site selection, disposal methods and dredged material stabilization. Disposal sites should, therefore, have the following characteristics:

- particle sizes as fine as or finer than the dredged materials;
- bottom slopes should not be steep;
- sites should not be adjacent to channels; and
- sites should have a low hydraulic energy (both bottom currents and storm erosion).

It is recommended to use disposal sites which have shown minimum dispersal, slumping or erosion of dredged materials in the past.

isposal methods which would aid in dredged material retention are:

- accurate placement of dredged materials; and
- timing of disposal so that water levels and currents would permit maximum settling and compaction.

Retention of dredged materials on-site can be fostered by:

- establishing aquatic or semi-aquatic vegetation as soon as possible where this is feasible.

5.3 Site Surveys

Components which are undertaken in site surveys should assist in the choice of the actual site and augment long-term monitoring by providing "pre-activity" data. Site specific factors to be measured include:

Bottom Erodability

- select an area of low hydraulic energy with similar particle size as the dredged sediments;
- obtain information on bottom currents;
- measure the particle size of the site sediments to obtain an estimate of bottom currents in the area; and
- use wave and storm hindcasting models to predict the effect of major storms on the hydraulic energy of the site.

Biological Community

- determine the speciation and biomass of the benthic community;
- determine the commercial and sport fishing in the area; and
- determine suitable biota (benthic organisms) which could be used in subsequent monitoring of bioaccumulation of contaminants.

Because of the cost of such data collection, it is advisable to make use of all available historical data supplemented by either diver or remote- operated vehicle observations. Once a site is chosen, more detailed information can be collected. In addition, the suspended solids (throughout water column) in the area should be characterized for quantity and contaminant concentrations. This data will provide a "pre-use" data base. Monitoring over a period of time may prove useful to allow for natural fluctuations in concentrations of contaminants. Data collection sites should be chosen on the basis of operational monitoring requirements.

6.0 CONFINED DISPOSAL FACILITIES

6.1 Purpose

Confined disposal facilities (CDFs) are appropriate when it is deemed necessary to isolate contaminated dredged materials from the environment. To lfil its role, a CDF must be designed and managed to retain the contaminated dredged materials without impairing the quality of the adjacent waters, and without creating subsequent contaminant pathways (e.g., dust, vegetative uptake, erosion). Because a CDF is a long-term structure it should be sited with a view to compatibility with existing and proposed land and water uses. The ministry is currently developing guidelines for lakefilling operations.

6.2 Under Water Containment

Traditionally, contaminated dredged materials have been placed in shoreline or upland containment facilities to remove and isolate the materials from the aquatic environment. However, the higher cost of on-land disposal, coupled with the significant environmental impacts, have led to the development of underwater "confinement" or "capping". This procedure is not a commonly used technique in Ontario but has been used in other areas such as the New York Bight.

ıere are three main concerns with open water disposal of contaminated sediments:

- erosion and off-site transport of the fine-grained sediments with which much of the contaminants are associated;
- interaction of colonizing benthos or bottom-feeding fish; and
- long-term transfer of contaminants into the overlying water column.

To overcome these concerns, the "borrow and fill," and "capping" techniques have been developed. In the borrow and fill technique, a large pit is excavated and the excavation material placed to one side for later use. The contaminated dredged material is placed in the pit and the excavated material used as cover. This offers the advantage of covering the site with sediment similar to the adjacent area and a cost savings by not having to transport cover material to the site. In the capping technique, the dredged material is placed at the disposal site and covered with a thin layer of uncontaminated material which will not be eroded from the site. In the past, this material was medium-coarse sand. A drawback to capping is the need to dredge sediment from another area and transport it to the disposal site. It is not recommended to use sand if the material being covered has a different texture, i.e., finer to prevent the cap from penetrating the less dense material. In these instances, fine, clean sediment should be used as the capping substrate. Careful placement has been a problem for projects attempted in Atlantic Canada. Typically, a cover volume of three to five times the volume of dredged sediments has been required to provide a cover of at least one metre (Bokuniewicz, 1981a,b; 1982).

Care has to be taken that the cover material does not displace nor inter-mix with the dredged sediments, and that the cap adequately covers all of the dredged materials.

6.3 Design and Operation Considerations of Shoreline and Upland CDFs

Several factors must be taken into consideration in the design and operation of shoreline and upland facilities. These include:

- Site Designation:
  - land ownership
  - municipal planning/zoning restrictions
  - public perception
  - adjacent land uses and restrictions
  - water lots and riparian rights
  - site accessibility
  - interference with longshore transport or susceptibility to erosion
  - geotechnical properties of site soil
  - geology and hydrogeology of site
  - capacity for enlargement

- **Facility Design:**
  - restrictions imposed by site designation review
  - physical and chemical nature of materials
  - method of material entry
  - allowance for over-dredging and volume increase due to entrained water
  - effluent quality requirements
  - drainage to receiving waters
  - long-term capacity requirements

- **Facility Usage:**
  - restrictions determined by site designation review
  - interference with normal navigational or recreational uses of waterway by disposal transportation
  - maintenance of site integrity (structural)
  - control of site accessibility
  - maintenance of effluent requirements

- **Facility De-Commissioning:**
  - isolation of dredged materials
  - maintenance of material integrity
  - restrictions on site accessibility
  - restrictions on site usage
  - long-term monitoring requirements

6.3.1 Site Designation

It is preferable to designate a site on property controlled by either the project proponent (e.g., Public Works Canada) or the project initiator (e.g., a harbour commission). However, consideration must be given to adjacent property ownership and uses. This may lead to a requirement for creation of a buffer zone. There may be specific municipal zoning or planning strategies controlling the use of the area, such as designation of the property under a holding zone for future recreational park or waterfront development. An important restriction on shoreline CDFs is waterlot and riparian rights. Siting of a CDF may deprive an adjacent landowner from access to waterborne transportation or the use of a waterway for cooling waters or effluent pipe right-of-way. Consultation with municipal planning authorities and local property owners should be considered at this stage.

Site accessibility is very important in site designation for CDFs. The transportation of dredged material can present a hindrance to other water uses: navigational or recreational use of the waterway can be hindered by barge traffic or the hydraulic pipeline on a suction dredge; special handling facilities may have to be constructed on the shoreline to accommodate double-handling; truck traffic to an upland facility may be restricted to select times, select routes and may require specially equipped trucks; hydraulic pipelines on a suction dredge may require special rights-of-way.

Engineering considerations in site evaluation must include the geotechnical, geological and hydrogeological characteristics of the site. Consideration must be given to the ability of the site to support the weight of the berms and the dredged materials without slumping or ground-faulting. Removal of soft underlying layers to stabilize berm foundations or the installation of special geotextiles may be required. Geological factors include depth of overburden, nature of overburden and underlying rock type and structure. Because many areas depend on groundwater for potable water supply, the hydrogeological characteristics of the site have to be reviewed and may lead to a requirement for a special liner. A special requirement of shoreline facility designation is interference with longshore transport and the susceptibility to erosion or over-topping. Evaluation of erosion and the use of protective armour stone may be required. The overall cost estimates for the facility should also include availability and transportation costs of material for berm construction.

Proper review of site designation factors can be very complicated and time-consuming. It may be advisable to construct a matrix chart in order to ensure that all factors are adequately considered and the cost components of each factor summarized. This way a meaningful comparison of factors and associated costs for each site may be made.

6.3.2 Facility Design

The design may have to be tailored to specific restrictions developed under the site designation stage; however, the main criteria will be the physical and chemical nature of the material to be confined. The design factor will include any regulatory restrictions on permitting dewatering and the quality of the dewatered effluent. The nature of the material may be such that special liners, increased control of the permeability of the berms, addition of settling agents and special effluent control mechanisms may be required.

If dewatering is permitted, then the CDF should be designed to minimize the loss of fine-grained particulate matter with which contaminants are most likely associated. The objective is to reduce the horizontal velocity of a sediment particle relative to its vertical sedimentation velocity. Sedimentation of the fine-grained particulate matter can be accomplished by:

- increasing the distance between the inlet and the effluent outlet;
- decreasing the horizontal velocity of the water between the inlet and the outlet (i.e., maximize travel time between inlet and outlet); and
- adding chemical(s) to increase the sedimentation rate.

Specific information of designs to promote settling can be found in Palermo *et al.* (1978); information on the addition of agents to promote flocculation and sedimentation can be found in Wang and Chen (1977) and Schroeder (1983).

The design must also consider the method by which the material is dredged and transported to the site. Hydraulic dredging typically yields a slurry of 3 to 20% solids content. The extra water must either be allowed to be drained off or the facility increased in size. The physical nature of the material will also be altered during the hydraulic dredging. This could lead to a subsequent problem of a very slow rate of settling of the dredged material in the containment facility.

The method of placing of material into the CDF can be critical in maintaining a reasonable rate of sedimentation inside the facility. The hydraulic pipeline should have a deflector plate on the end to reduce the input velocity and to prevent erosion of the inner walls of the berms. Log booms may also be required near the entry point to further reduce horizontal velocity and to retain any surface froth and scum.

Facility capacity should take into consideration:

- potential over-dredging;
- extra volume requirements created by water entrained by the hydraulic dredging process;
- effluent specifications; and
- long-term requirements for dredging at the project site.

The stated purpose of placing the dredged material in the CDF was to prevent dispersal of contaminated sediment subsequent to the dredging operation. Because contaminants are preferentially associated with fine-grained sediments, most effluent controls will be based on a control of the suspended sediments content of the effluent. Design of the effluent control mechanisms to maximize the retention of suspended solids and to minimize the effort to accomplish this task is one of the most important components of the facility design. Effluent controls typically consist of weirs which are sections of the berm at lower elevation and are covered with a coarse gravel (to prevent erosion). More elaborate controls can consist of special geotextiles or semi-permeable berms, flow control valves or a series of overflow pipes. Guidelines regulating the quality of the effluent may be a combination of province-wide regulations and the quality of the receiving waters.

Drainage of the dewatering effluent from a shoreline CDF is relatively simple, taking into account potential for erosion of undermining of the effluent structure. Drainage from an upland site must take into consideration the stream flow characteristics of the receiving stream so as to minimize the /sical impact on that receiving waterbody.

6.3.3 Facility Usage

Restrictions on the operation of the facility can be created by other users of the waterway affecting both the dredging operation and the transportation of dredged materials to the CDF. These users can include both commercial and recreational craft. Other restrictions can be caused by commercial fishing operations or seasonal limitations to protect fish migrations or larval development.

Maintenance of site integrity should be relatively simple if careful planning and design is incorporated into the site designation and facility design stages. Contingency plans may have to be developed to accommodate berm slumping (due to site degradation) or failure to meet dewatering effluent requirements. Site integrity can also be maintained by careful regulation of other users (i.e., other dredged material disposal operations) of the site, as well as regulation of public access to the site to reduce liability due to accidents and the disposal of garbage and other miscellaneous wastes. If the facility will be actively used over a number of years, control of re-vegetation and use of the facilities by migratory birds and other wildlife may have to be instituted.

6.3.4 Facility De-Commissioning

The first stage in de-commissioning is to ensure the long-term encapsulation of the dredged materials. This may entail the covering of the site with a special membrane or clay liner or simple in-filling to "bury" the materials. This over-burden will also serve to increase the geotechnical strength of the site, thereby increasing its potential subsequent use. A good example is the Pier 26 development in Hamilton. There, the dewatered sediment has been covered with layers of slag waste from an adjacent steelmaking facility which serves to both dispose of the slag and to provide a cover for the CDF.

Long-term monitoring is often required as many of the potential chemical processes within the dredged sediments occur over long periods of time. Specific discussion on the chemical reactions and potential leaching that can occur can be found in Gambrell *et al.* (1978) and Chen *et al.* (1978). Such monitoring will also assess the potential for infiltration from surface or groundwaters. Provision for monitoring wells and drainage systems may be required.

The CDF can be designed and operated to facilitate other uses after de-commissioning. Detailed discussion of re-use management can be found in Montgomery *et al.* (1978). These uses could include industrial land, land to augment port facilities (e.g., storage of containers), or recreational lands. Each subsequent use must be evaluated for its own special requirements ranging from geotechnical properties of the site through to the potential implications for long-term leaching of chemical constituents from the site. Vegetation of the de-commissioned site may be desirable but must be controlled to inhibit the uptake of contaminants into the vegetation (Folsom *et al.* 1981). This particularly applies to agricultural use of the site. The overall cost/benefit evaluation of a dredging project can include subsequent use of a CDF.

6.4 CDF Examples

Since the early 1970's the shoreline or upland CDF option has been the most commonly used mode of disposal for dredged materials in the Great Lakes both in Canada and the United States. The primary purpose was to restrict the dispersion of contaminated sediments which was believed to be occurring from open water sites and to remove contaminated sediments from the Great Lakes thereby assisting in the improvement of water quality.

Detailed information on specific CDFs can be obtained from Public Works Canada (Ontario Region, Toronto or Marine Directorate, Ottawa) or U.S. Army Corps of Engineers District Offices (Buffalo, N.Y., Detroit, Michigan or Chicago, Illinois). In most cases, the information is in the form of internal reports/memos. More detailed information on the design and management of nfined disposal facilities can be found in Palermo *et al.* (1978), Hunt *et al.* (1978), Walsh and Malkasian (1978) and subsequent unpublished reports by the U.S. Army Corps of Engineers.

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GLOSSARY

EARP - Environmental Assessment and Review Process

OMOE - Ontario Ministry of the Environment

FWPCA - U.S. Federal Water Pollution Control Administration

EPA - U.S. Environmental Protection Agency

CDF - Confined disposal facility

IJC - International Joint Commission

NOAA - U.S. National Oceanic and Atmospheric Administration

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Appendix A

Evaluation of Dredged Material for Suitability for Open Water Disposal

(Reprinted from Persaud *et al.* 1992)

Assessment of the Suitability of Dredged Material for Open Water Disposal

Dredged material refers to any material removed from the bottom of a watercourse as a result of capital or maintenance dredging, remedial action or spills clean-up. The conditions outlined below relate only to material being considered for disposal in open water and does not include material to be placed within Confined Disposal Facilities (CDFs). Analyses will be performed for all parameters listed in Tables A.1 and A.2a, unless previous data suggest the absence of certain parameters. Chemical analysis for compounds listed in Table 2b will be performed where specifically requested by MOE or where there is reason to suspect contamination by PAH compounds. In addition, chemical analysis may be required for some or all of the parameters in Table A.3 on a case specific basis.

A. Disposal in Areas With Sediment Quality Equal to or Better Than the No Effect Level Guidelines.

The dredged material to be disposed of must not exceed the No Effect Level Guidelines.

B. Disposal in Areas With Sediment Quality Exceeding the No Effect Level Guidelines.

The dredged material to be disposed of in such areas must be below the Lowest Effect Level Guidelines, subject to the conditions described below:

(i) The Ministry recognizes that in an area as geologically diverse as Ontario, local natural sediment levels of the metals may vary considerably and in certain areas, such as wetlands, the organic matter content and nutrient levels may be naturally high.

Table A.1: **Provincial Sediment Quality Guidelines for Metals and Nutrients.**
(values* in ug/g (ppm) dry weight unless otherwise noted)

METALS	No Effect Level	Lowest Effect Level	Severe Effect Level
Arsenic	-	6	33
Cadmium	-	0.6	10
Chromium	-	26	110
Copper	-	16	110
Iron (%)	-	2	4
Lead	-	31	250
Manganese	-	460	1100
Mercury	-	0.2	2
Nickel	-	16	75
Zinc	-	120	820
NUTRIENTS			
TOC (%)	-	1	10
TKN	-	550	4800
TP	-	600	2000

* - values less than 10 have been rounded to 1 significant digit. Values greater than 10 have been rounded to two significant digits except for round numbers which remain unchanged (e.g., 400).

"-" - denotes insufficient data/no suitable method.

TOC - Total Organic Carbon TKN - Total Kjeldahl Nitrogen TP - Total Phosphorus

METALS: In areas where local background levels are above the Lowest Effect Level, the local background level will form the practical lower limit for management decisions. In some waterbodies surficial sediments upstream of all discharges may be acceptable for calculation of background values. Where it cannot be shown that such areas are unaffected by local discharges, the pre-colonial sediment horizon is used. Site specific background for metals is calculated as the mean of 5 replicate samples from surficial sediment that has not

Table A.2a: Provincial Sediment Quality Guidelines for PCBs and Organochlorine Pesticides.
(values[a] in $\mu g/g$ (ppm) dry weight unless otherwise noted)

Compound	No Effect Level	Lowest Effect Level	Severe Effect Level ($\mu g/g$ organic carbon)*
Aldrin	-	0.002	8
BHC	-	0.003	12
α-BHC	-	0.006	10
β-BHC	-	0.005	21
γ-BHC	0.0002	(0.003)[b]	(1)[c]
Chlordane	0.005	0.007	6
DDT(total)	-	0.007	12
op+pp-DDT	-	0.008	71
pp-DDD	-	0.008	6
pp-DDE	-	0.005	19
Dieldrin	0.0006	0.002	91
Endrin	0.0005	0.003	130
HCB	0.01	0.02	24
Heptachlor	0.0003	-	-
H epoxide	-	0.005[b]	5[c]
Mirex	-	0.007	130
PCB(total)	0.01	0.07	530
PCB 1254[d]	-	(0.06)[b]	(34)[c]
PCB 1248[d]	-	(0.03)[b]	(150)[c]
PCB 1016[d]	-	(0.007)[b]	(53)[c]
PCB 1260[d]	-	(0.005)[b]	(24)[c]

Lowest Effect Levels and Severe Effect Levels are based on the 5th and 95th percentiles respectively of the Screening Level Concentration (SLC) (see Section 4.2.4) except where noted otherwise.

( ) Denotes tentative guidelines

[a] - Values less than 10 have been rounded to 1 significant digit. Values greater than 10 have been rounded to 2 significant digits except for round numbers which remain unchanged.

[b] - 10% SLC.

[c] - 90% SLC.

[d] - Analyses for PCB Arochlors are not mandatory unless specifically requested by MOE.

\- Insufficient data to calculate guideline.

* Numbers in this column are to be converted to bulk sediment values by multiplying by the actual TOC concentration of the sediments (to a maximum of 10%), e.g. analysis of a sediment sample gave a PCB value of 30 ppm and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 530 x 0.05 = 26.5 ppm as the Severe Effect Level guidelines for that sediment. The measured value of 30 ppm is then compared with this bulk sediment value and is found to exceed the guideline.

Table 2b: Provincial Sediment Quality Guidelines for Polycyclic Aromatic Hydrocarbons.
(values in $\mu g/g$ (ppm) dry weight unless otherwise noted)

Compound	No Effect Level	Lowest Effect Level ($\mu g/g$ organic carbon)*	Severe Effect Level
Anthracene	-	0.220	370
Benz[a]anthracene	-	0.320	1,480
Benzo[k]fluoranthene	-	0.240	1,340
Benzo[a]pyrene	-	0.370	1,440
Benzo[g,h,i]perylene	-	0.170	320
Chrysene	-	0.340	460
Dibenzo[a,h]anthracene	-	0.060	130
Fluoranthene	-	0.750	1,020
Fluorene	-	0.190	160
Indeno[1,2,3-cd]pyrene	-	0.200	320
Phenanthrene	-	0.560	950
Pyrene	-	0.490	850
PAH (total)	-	4	10,000

(Guidelines could not be calculated for Acenaphthene, Acenaphthylene, Benzo[b]fluorene and Naphthalene due to insufficient data. These will be calculated when sufficient data is available.)

Lowest Effect Levels and Severe Effect Levels are based on the 5th and 95th percentiles respectively of the Screening Level Concentration (SLC) (see Section 4.2.4) except where noted otherwise.

- Insufficient data to calculate guideline.

* Numbers in this column are to be converted to bulk sediment values by multiplying by the actual TOC concentration of the sediments (to a maximum of 10%), e.g. analysis of a sediment sample gave a B(a)P value of 30 ppm and a TOC of 5%. The value for B(a)P in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% TOC by multiplying 1443 x 0.05 = 72 ppm as the Severe Effect Level guideline for that sediment. The measured value of 30 ppm is then compared with this bulk sediment value and is found to not exceed the guideline.

PAH (total) is the sum of 16 PAH compounds: Acenaphthene, Acenaphthylene, Anthracene, Benzo[k]fluoranthene, Benzo[b]fluorene, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[g,h,i]perylene, Chrysene, Dibenzo[a,h]anthracene, Fluoranthene, Fluorene, Indeno[1,2,3-cd]pyrene, Naphthalene, Phenanthrene and Pyrene.

Table A.3: Additional Parameters.
Parameters carried over from the Open Water Disposal Guidelines (1976).

Parameter	Guideline
Oil and Grease	0.15%
Cyanide	0.1 ppm
Ammonia	100 ppm
Cobalt	50 ppm
Silver	0.5 ppm

Routine testing for these parameters would not be required but may be requested on a case-specific basis.

been directly affected by man's activities or from the 'pre-colonial' sediment horizon. The calculations are described in Section 4 of the Ministry's "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario" and are reproduced below:

> The mean of 5 surficial sediment samples (top 5 cm) taken from an area contiguous to the area under investigation, but unaffected by any current or historical point source inputs.

Table A.4: Background Levels for the Metals

Metal	Background ($\mu g/g$)
Arsenic	4.2
Cadmium	1.1
Chromium	31
Copper	25
Iron (%)	3.12
Lead	23
Manganese	400
Mercury	0.10
Nickel	31
Zinc	65

Values are based on analyses of Great Lakes pre-colonial sediment horizon.

Table A.5: Background Sediment Concentrations* of Organic Compounds.

Compound	Background ($\mu g/g$ dry wt.)
Aldrin	0.001
α-BHC	0.001
β-BHC	0.001
γ-BHC	0.001
Chlordane	0.001
DDT (total)	0.01
op+pp DDT	0.005
pp-DDD	0.002
pp-DDE	0.003
Dieldrin	0.001
Endrin	0.001
HCB	0.001
Heptachlor	0.001
Heptachlor epoxide	0.001
Mirex	0.001
PCB (total)	0.02

* Values are based on the highest of the Lake Huron or Lake Superior mean surficial sediment concentrations.

or:

The mean of 5 samples taken by a sediment core from the pre-colonial sediment horizon. The pre-colonial horizon is generally determined as the sediment below the *Ambrosia* sediment horizon. Except in areas of high sedimentation, such as river mouths, this can be estimated as that sediment lying below the 10 cm sediment depth.

Alternatively, the mean background values for the Great Lakes Basin as presented in Table A.4 may be used.

NUTRIENTS: Areas of high natural organic matter content, such as marshes and other types of wetlands, can be readily distinguished from those resulting from anthropogenic sources. In such cases, for the nutrients listed in Table A.1, the local background would serve as the practical lower limit for management action.

(ii) It is also recognized that long-range sources such as atmospheric deposition have contributed to accumulation of organic compounds in areas remote from any specific source. Therefore, in those areas where specific sources cannot be determined, the practical lower limit for management action is the Upper Great Lakes deep basin surficial sediment concentration. These have been defined for a number of organic compounds and are presented in Table A.5.

Detailed application of these guidelines is described below and is shown in Figure 1.

Sediment Evaluation for Dredged Material Disposal

Dredge material disposal in open water requires that both the material to be removed as well as the material in the disposal area be analyzed. Each parameter is compared to the PSQG levels. In practice, the material is matched to the disposal area, which in turn will be classified into one of three groups.

Group 1

1a. The concentrations of contaminants in sediments in the disposal area are below the No Effect Level. If the concentrations in the dredged material are also below the No Effect Level the material is suitable for disposal at this site.

1b. If the concentrations in the dredged sediments are above the No Effect Level then this material is not suitable for disposal at this site, since this would result in contamination of a clean site with sediment of a lesser quality. However, if the concentrations in the dredged material are below the Lowest Effect Level, it may be suitable for disposal at another site where existing sediment concentrations are above the No Effect Level.

1c. Material that exceeds the Lowest Effect Level for any parameter is not

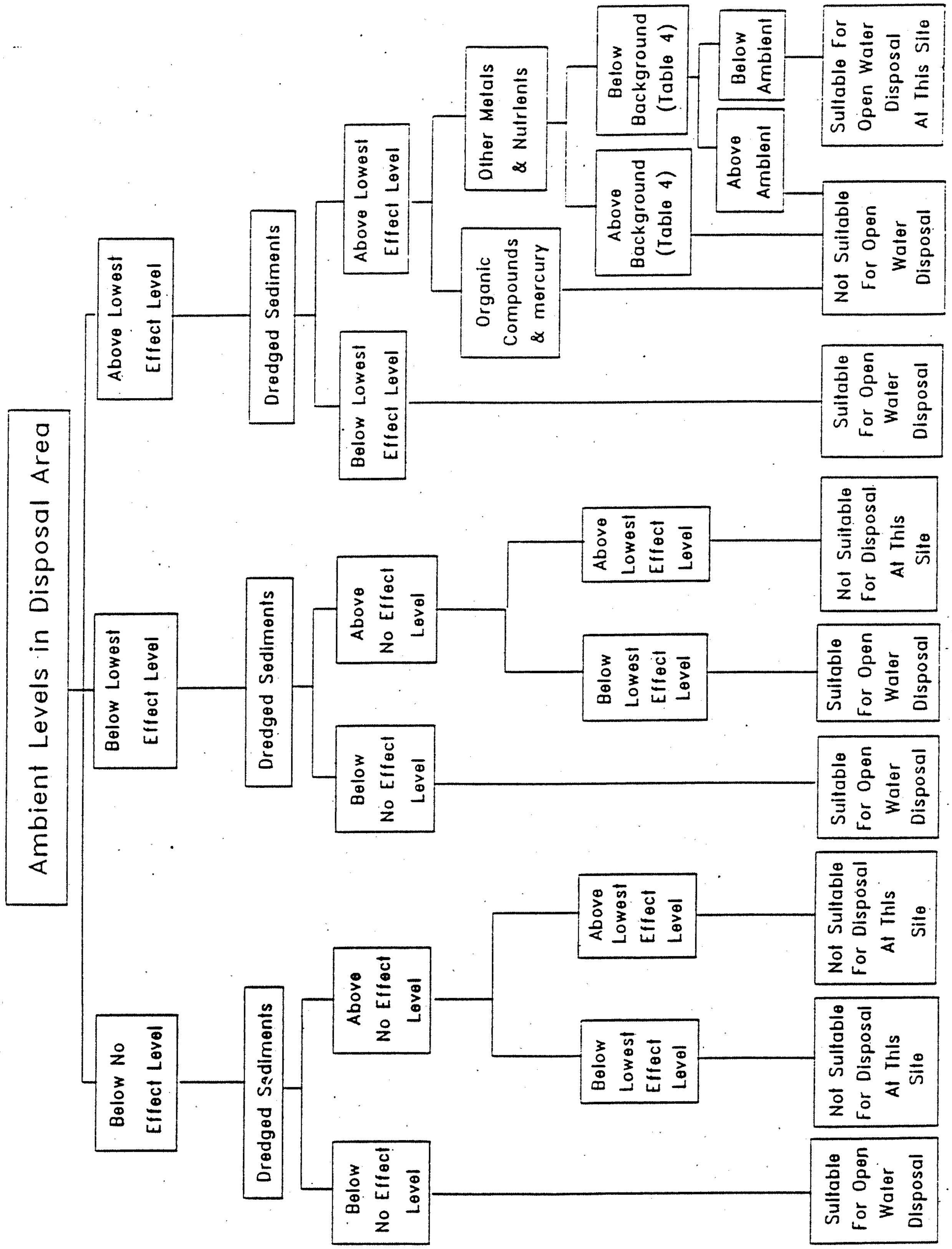

Figure A.1: Application of Provincial Sediment Quality Guidelines to Dredging Activities suitable for open water disposal at this site.

Group 2

2a. The sediments in the disposal area are above the No Effect Level but still below the Lowest Effect Level. If the concentrations in the dredged material are below the No Effect Level then the material is suitable for open water disposal at this site.

2b. Similarly, if the dredged material is above the No Effect Level but below the Lowest Effect Level, the material is also suitable for disposal at this site. Material that exceeds the Lowest Effect Level is not suitable for open water disposal at this site.

Group 3

3a. If the sediments in the disposal area are contaminated to above the Lowest Effect Level, material that is below the Lowest Effect Level is suitable for open water disposal at this site.

b. Material that exceeds the Lowest Effect Level for organic compounds and mercury is not suitable for open water disposal. Material that exceeds the Lowest Effect Level for metals other than mercury is suitable for open water disposal under certain conditions. If the material is at or below the Great Lakes background (as defined in Table A.4) and does not exceed ambient sediment levels then the material is suitable for open water disposal at this site.

General Conditions Governing Evaluation

In addition to the site specific conditions described above, the following general conditions will also apply to sediment assessment for the purposes of dredged material evaluation and disposal.

(a) Material will be tested by bulk sediment analyses and results reported on a dry weight basis (MOE Analytical Methods (MOE 1983) or MOE approved equivalent analytical procedures to be used).

(b) For the purposes of sediment or fill quality evaluation, actual analytical results reported by the performing laboratory must be provided. However, in comparing the results with the parameter values in the guidelines the results will be rounded as follows: if the reported value is less than ten, it will be rounded to one significant digit. Values greater than 10 will be rounded to two significant digits. Round numbers remain unchanged.

e.g.	Reported Value	Rounded Value
<10	1.78	2
	0.0364	0.04
	0.0052	0.005
>10	10.827	11
	128.4	130

(c) If all parameter values for a given material are <u>at or below</u> the No Effect Level Guidelines, that material passes the guideline and it is anticipated that the material will have no adverse chemical effects on aquatic life or water quality.

(d) If a single parameter value for a given material, based on a sampling program, <u>exceeds</u> the No Effect Level Guideline but is below the Lowest Effect Level Guideline, the material fails the No Effect Level Guidelines and would be considered as having a negligible potential to impair the aquatic environment.

(e) If a single parameter value for a given material, based on a sampling program, is <u>at or above</u> the Lowest Effect Level Guidelines, that material fails the guideline and it is anticipated that such material may have an adverse effect on some benthic biological resources. If all values <u>are below</u> the Lowest Effect Level Guidelines, no significant effects on benthic biological resources are anticipated.

(f) If any single parameter value for a given material, as determined by a sampling program, is <u>at or above</u> the Severe Effect Level Guideline, that material is considered <u>highly contaminated</u> and will likely have a significant effect on benthic biological resources.